

# Application of Conjectural Variation to Japanese Steel Industries

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**ABSTRACT** : After the devastating damages of East Japan Earthquake, we investigate the affection of supply in steel. There are several steel companies in Japan such as Nippon Steel Corporation, JFE Steel Corporation, Sumitomo Metal Industries, Ltd and Kobe Steel, Ltd. Namely, steel industries are mainly controlled these four companies. So, we grasp this status as “Oligopoly”. And we also mention this as a homogeneous oligopolistic market. Suppose that the supply level of Nippon Steel Corporation is decreased due to the earthquake. If this situation will occur, how will it affect another steel company’s price of the same product? We use the concept of “Conjectural Variation” to resolve this problem. Conjectural variation means the volatility of another companies supply levels which Nippon Steel Corporation will conjecture when Nippon Steel Corporation will decrease (or increase) its supply level. Thus, if each company will determine its supply level to maximize its profit in a homogeneous oligopolistic market, the price level is written by the three factors such as elasticity of price, marginal cost and conjectural variation. Here, we add three suppositions. Firstly, price elasticity of a certain product is constant temporarily regardless of the total demand level. Secondly, marginal cost in each company is constant regardless of the production level within its production capacity. Thirdly, conjectural variation in each company is constant in each fiscal term. Based on former three suppositions, price will be determined prior to demand level. Finally, we investigate how conjectural variation’s change will affect the price level. The result is that if a company’s marginal cost is minimized, the increase (or decrease) of the company’s conjectural variation will occur the increase (or decrease) of price level under the conditions that given another situations are equal.

**KEYWORDS** : East Japan Earthquake, Homogeneous oligopolistic Market, Conjectural Variation,

## 1. INTRODUCTION

East Japan Earthquake gave devastating damages to the east of Japan. Concerning Nippon Steel Corporation, “Kamaishi” long products plant located away from the recent earthquake 300 kilometers north of Sendai City, in this disaster, and although the electric wire rod production line did not suffer damage, but because of the Kamaishi port was destroyed by the tsunami, the terminal equipment has been flooded can not complete the normal delivery, a number of factory workers and their families are still recognized in the security situation, expected to be long discontinued. Nippon Steel has been in the Kamaishi area has an annual capacity of

60 million tons of bars, wire integrated plant, has stopped all production, reconstruction and resumption of production is also expected to take considerable time. To make up for Kamaishi problems, the company plans to increase its “Muroran” by factories and “Kimitsu” wire production plant as soon as the supply of raw materials to carry out reconstruction work.

Kimitsu steel mills located in the eastern part of Tokyo Bay, is Nippon Steel's largest steel mill last year, crude steel production of 590 million tons. Currently, the steel is in a safe, based on a comprehensive inspection of equipment and embankment protection, the previous check and shut

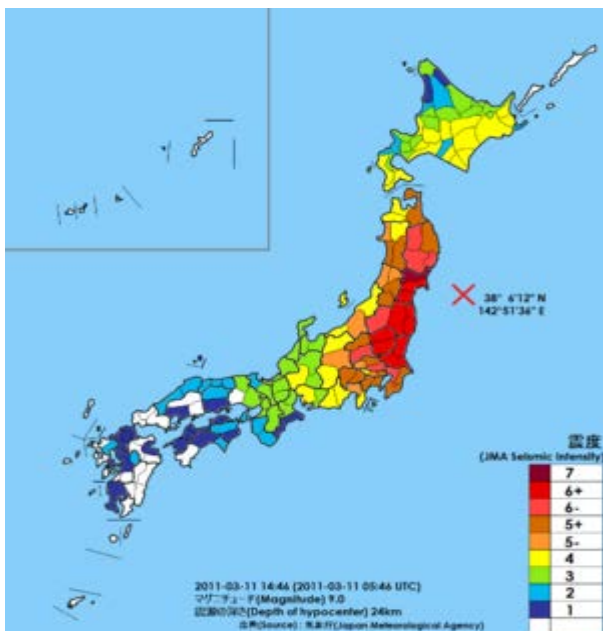
down due to the 3 blast furnace has restarted one by one, at the downstream operations have also restarted. To March 13, blast furnace has been restored in full operation, while rolling equipment has resumed operation. Steel mills in the south bank of Muroran, Hokkaido, from Nippon Steel and Mitsubishi Steel (MitsubishiSteelWorks) HokkaiIron & Coke joint venture responsible for the operation, the steel mills in this disaster has not affected the larger damage. Nippon Steel long products than Kamaishi the most serious damage to plants, other steel mills (Kimitsu steel mills, steel mills Muroran, Yahata steel mills and steel mills wide x) are subject to little effect, but after receiving the tsunami warning, immediately stop the coastal vessels are the beginning of flight, to be shipped early warning lifted after the restoration. JFE Steel Corporation Chiba in the western Gulf of Tonkin, before its output to 257 million tons. After the earthquake on the 11th, was immediately off the wind, the morning of 14 restored blast furnace. But the alleged production of hot metal will remain in the "minimum level." In addition, the mill equipment is also being in a "stop point inspection" status, in line with the Government of Japan's "limited power" measures, when the production line to resume production has not been determined. Keihin JFE Steel Corporation in the western Gulf of Tonkin, before the annual output is 270 tons. After the earthquake on the 11th, was immediately off the wind, 13 blast furnace restored, but its hot metal production will remain in the "minimum level." Similarly, the rolling mill is still in a "stop point inspection" status, in line with "limited power" measures, production line to resume production time has not yet determined. JFE plate company (JFEBars & Shapes) steel mill in the near Sendai in Sendai Bay, is in Kashima JFE steel plate, before its annual production of about 80 million tons of crude steel. Earthquake and tsunami, the plant is submerged, is still recognized in the current

information. It is reported that the loss of Sendai and port areas are more serious. Northeast Steel Corporation (TohokuSteel) is also located near Sendai Bay, which until about 264,000 tons of crude steel production / year. Earthquake and tsunami, the plant is submerged, is still recognized in the current information.

While, Sumitomo Metal Industries (SMI)'s case, Kashima iron works this hard-hit in Ibaraki Prefecture, the situation is relatively higher than other steel mills by the severe earthquake, the steel crude steel production was 5.7 million tons last year. In the 11 earthquake, a fire of coke oven gas related equipment, and was extinguished at 12 early in the morning. In addition, the two blast off in the wind after the earthquake has been in a state, there is still no air, when the re-supply air blast is not yet known. Plate, car plate rolling mill and related equipment is currently in a "stop point inspection" status, is hard to determine when to resume production. Just turn around in 2010 for the Japanese iron and steel enterprises, the earthquake and power outage short-term impact on the industry giant. Japan's crude steel, hot rolled coil production accounted for 8% of global production and 7%, Japan's major steel enterprises stop production, will shortly be down the country's steel imports and the global iron ore prices. Nippon Steel has the company's iron-making plant in Kamaishi, or long-term cease production, the company consider allowing other plants instead of shipping their production in response to the task. Affected by the tsunami, Nippon Steel is currently in Japan all have suspended shipping iron plant, the company plans tsunami warning lifted after the restoration of all plants except Kamaishi shipments outside. Sumitomo Metal Industries, Kashima, Ibaraki Prefecture is located in the blast furnace steel plant damage, the blast furnace flameout has been discontinued after the earthquake. Japan's JFE's steel plant located in Chiba has also undergone a fire.

These enterprises are unable to recover in the short term production. Japan Iron and Steel Union, the data show that in 2009 and 2010, the affected area accounted for steel orders for basic steel products in Japan about 30% of the total order, so the short term some varieties of steel exports to Japan will be affected. The affected enterprises from the current main product mix, the main affected areas of the steel companies to produce sheet and tube-based, reduced steel output in the region will inevitably lead to market resources supply, thus pushing up prices of related products. However, from the medium to long term, post-disaster reconstruction needs a lot of steel, and the gradual return to work with the manufacturing industry, steel demand will surge, increasing the volatility of steel prices. In addition, significant increase in the scrap after the earthquake, the international scrap prices will also have an impact. The following is the map of this earthquake. Judging from the map, except for Kobe Steel, Ltd, large “oligopolistic” steel companies such as Nippon Steel Corporation, JFE Steel Corporation and Sumitomo Metal Industries, Ltd are more or less affected by this earthquake.

Figure 1. Earthquake Map in Japan



## 2. MODEL OF CONJECTURAL VARIATION

We assume a product, which is homogeneous and that purchasers will prefer any products without discrimination under the same price. Suppose that there are many purchasers, but the numbers of sellers are extremely limited and each sellers can somewhat affect the price of the product. This is called as an oligopolistic Market. Let the total demand for this product be  $D$ , the price be  $p$ , and the market demand function be  $p = f(D)$  .....(1)

The first derivative of which is assumed to be negative for any positive  $D$ . Namely, we suppose that  $f'(D) < 0$  .....(2)

Let the number of firms be  $n$  and the supply of the  $j$ th firm be  $q_j$ . Then the total supply

$$S = q_1 + q_2 + \dots + q_n \text{ must be equal to } D .$$

That is,  $D = q_1 + q_2 + \dots + q_n$  .....(3)

We assume that each firms will take profit maximizing behavior. Defining profit as  $\pi_j = R_j - C_j$ , where

$R_j$  and  $C_j$  are total revenue and cost respectively,

the marginal revenue may be expressed as

$$\begin{aligned} \frac{dR_j}{dq_j} &= \frac{d(pq_j)}{dq_j} = p + \frac{dp}{dq_j} q_j = p + \frac{dp}{dD} \frac{dD}{dq_j} q_j \\ &= p + \frac{dp}{dD} \left[ 1 + \frac{d}{dq_j} \left( \sum_{k \neq j} q_k \right) \right] q_j \dots\dots\dots(4) \end{aligned}$$

$$\therefore \gamma_j = \frac{d}{dq_j} \left( \sum_{k \neq j} q_k \right) \dots\dots\dots(5)$$

Namely, marginal revenue is

$$\frac{dR_j}{dq_j} = p + \frac{dp}{dD} \left( 1 + r_j \right) q_j \dots\dots\dots(6)$$

Here,  $\gamma_j$  is a conjectural variation. This is the ratio of the variation of the other firm’s supply which firm  $j$  assumes will result if it increases its own supply.

The first order condition for profit maximization is

$$p + \frac{dp}{dD} (1 + r_j) q_j - c_j = 0, j=1,2,\dots,n \dots\dots\dots(7)$$

Here,  $c_j$  is a marginal expense in each firm of the product. In addition, the second order condition of profit maximization is

$$\left( 2 + 2r_j + \frac{dr_j}{dq_j} q_j \right) \frac{dp}{dD} + (1 + r_j)^2 \frac{d^2 p}{dD^2} q_j - \frac{dc_j}{dq_j} < 0$$

$$j=1,2,\dots,n \dots\dots\dots(8)$$

If the price elasticity of demand is denoted by  $\alpha < 0$ , equation (7) can be expressed as

$$p + \frac{1}{\alpha} \frac{p}{D} (1 + r_j) q_j - c_j = 0 \quad j=1,2,\dots,n \dots\dots\dots(9)$$

$$\therefore \alpha = \frac{dD}{dp} \frac{p}{D}, \quad dD/dp < 0, \quad \text{and}$$

$$dp/dD = (1/\alpha)p/D.$$

Then, the market share of firm  $j$ ,  $q_j/D$ , may be

$$\text{expressed as } \frac{q_j}{D} = -\frac{\alpha}{p} \frac{p - c_j}{1 + r_j}, j=1,2,\dots,n \dots\dots(10)$$

$$\therefore 1 + r_j \neq 0$$

If we sum up this relation over  $j$ , it produces

$$\sum_{j=1}^n \frac{q_j}{D} = -\frac{\alpha}{p} \sum_{j=1}^n \frac{p - c_j}{1 + r_j} \dots\dots\dots(11)$$

While, left-hand side is equal to one, thus, it can be

$$\text{rewritten as } 1 = -\frac{\alpha}{p} \sum \frac{p - c_j}{1 + r_j} \dots\dots\dots(12)$$

If we solve equation (12) for  $p$ ,

$$p = \frac{\alpha \sum_{j=1}^n \frac{c_j}{1 + r_j}}{1 + \alpha \sum_{j=1}^n \frac{1}{1 + r_j}} \dots\dots\dots(13)$$

If each firms determine their supply quantity to maximize profit in homogeneous oligopolistic

markets, price level is expressed as a function of

three factors :  $\alpha$ ,  $c_j$ ,  $r_j$ . To simplify the sign, we

$$\text{put } \beta_j = \frac{1}{1 + r_j} \dots\dots\dots(14)$$

Thus, we can rewrite equation (13) as

$$p = \frac{\alpha \sum \beta_j c_j}{1 + \alpha \sum \beta_j} \dots\dots\dots(15)$$

We now introduce the following three assumptions.

Assumption 1 : The price elasticity of market demand  $\alpha$  is constant regardless of the level of demand.

Assumption 2 : The marginal cost  $c_j$  of each firm is constant with respect to its short-run variation in output.

Assumption 3 : The conjectural variation  $r_j$  is a constant parameter for each firm in each period.

Although these assumptions are introduced as a first approximation, they are not unrealistic. The first assumption of constant price elasticity is frequently used in empirical demand analyses because the log-linear type demand functions have produced good results. The second assumption of constant marginal cost has a great deal of evidence to support it. The third assumption means that each oligopolist ex ante has some definite conjecture about his rivals' attitudes. Based on these assumptions, price is predetermined for the demand level.

$$\text{From assumption 1, } \frac{dp}{dD} = \frac{1}{\alpha} \frac{p}{D} \dots\dots\dots(16)$$

$$\frac{d^2 p}{dD^2} = \frac{1}{\alpha} \left( \frac{1}{\alpha} - 1 \right) \frac{p}{D^2} \dots\dots\dots(17)$$

$$\text{From assumption 2, } \frac{dc_j}{dq_j} = 0 \dots\dots\dots(18)$$

$$\text{From assumption 3, } \frac{dr_j}{dq_j} = 0 \dots\dots\dots(19)$$

Using these four conditions, the second order

condition (8) becomes

$$\frac{1}{\alpha} \frac{p}{D} (1+r_j) \left[ 2 + (1+r_j) \left( \frac{1}{\alpha} - 1 \right) \frac{q_j}{D} \right] < 0 \dots\dots\dots(20)$$

In this inequality, if we assume  $r_j \leq -1$ ,  $1+r_j \leq 0$ . And  $\alpha < 0$ , then,  $1/\alpha - 1 < 0$ . Thus, the inside of bracket in (20) will be positive. As  $(1+r_j)/\alpha$  is also non-negative, the inequality (20) will not hold. So,  $r_j > -1$ .....(21) must hold to satisfy the second order condition.

### 3. Nippon Steel Corporation Case

If we apply the former model to Nippon steel Corporation Case, the upper limit of it is as follows.

$$r_j < -\frac{2\alpha}{1-\alpha} \frac{D}{q_j} - 1 \dots\dots\dots(22)$$

For example,  $\alpha = -1$  and ratio of occupancy  $q_j/D$  is 0.5, then,  $r_j < 1$ . While,  $q_j/D$  is 0.2, then,  $r_j < 4$ . And if  $r_j > -1$ , it means  $1/\beta_j > 0$ .  $\beta_j$  must be positive. Next, we investigate how affect the change of conjectural variation  $\gamma_j$  for the price level  $p$ . If we differentiate the equation (15),

$$\frac{\partial p}{\partial r_j} = -\alpha \frac{c_j + \alpha \sum_{\kappa=1}^n (c_j - c_{\kappa}) \beta_{\kappa}}{\left( 1 + \alpha \sum_{\kappa=1}^n \beta_{\kappa} \right)^2} \beta_j^2 \dots\dots\dots(23)$$

As  $\beta_{\kappa} > 0$ , if  $c_j \leq c_{\kappa}$  in all  $\kappa$ ,  $\partial p/\partial r_j > 0$ .

Thus, if we call minimized marginal cost firm as most excellent one, the most excellent firm's increase of conjectural variation will bring the increase of the price level and vice versa. Nippon Steel Corporation (Sales Shares : 26.0%) will surely become one case in point. For example, the affect between change of conjectural variation and price level of other firms such as

JFE Steel Corporation (Sales Shares : 21.2%), Kobe Steel, Ltd (Sales Shares : 12.5%) and Sumitomo Metal Industries, Ltd (Sales Shares : 9.6%) will highly depend on the positiveness or negativeness of

$$c_j + \alpha \sum_{\kappa=1}^n (c_j - c_{\kappa}) \beta_{\kappa} \dots\dots\dots(24)$$

Finally, we mention about the relationship of each

$$\text{firm's price elasticity of demand } \eta_j = \frac{dq_j p}{dp q_j} \dots\dots(25)$$

and conjectural variation  $\gamma_j$ .

According to the definition of price elasticity of the market, we can introduce following equation.

$$\alpha = \frac{dD}{dp} \frac{p}{D} = \left( \frac{dD}{dq_j} \frac{dq_j}{dp} \right) \left( \frac{p}{q_j} \frac{q_j}{dp} \right) = \left( \frac{dq_j}{dp} \frac{p}{q_j} \right) \left( \frac{dD}{dq_j} \right) \left( \frac{q_j}{D} \right) \dots\dots\dots(26)$$

Thus,  $\alpha = \eta_j (1+r_j) \frac{q_j}{D} \dots\dots\dots(27)$

If we rewrite (27) in  $\eta_j$

$$\eta_j = \frac{\alpha}{(1+\gamma_j) \left( \frac{q_j}{D} \right)} \dots\dots\dots(28)$$

Thus, the larger conjectural variation  $\gamma_j$  is, the

smaller  $|\eta_j|$  is under the conditions that both price elasticity and occupancy ratio in the market.

### 4. CONCLUSION

We investigate how conjectural variation's change will affect the price level. The result is that if a company's marginal cost is minimized, the increase (or decrease) of the company's conjectural variation will occur the increase (or decrease) of price level under the conditions that given another situations are equal. We apply the concept of conjectural variation for Nippon Steel Corporation. We notice that most

excellent firm is Nippon Steel Corporation. Thus, the increase (or decrease) of Nippon Steel Corporation's conjunctural variation will occur the increase (or decrease) of price level of the product.

The remaining problem is an empirical analysis of it.

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